REPORT DOCUMENTATION PAGE

Form Approved OMB NO. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
02-09-2015	Final Report	1-Jun-2012 - 31-May-2015

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Final Report: Consensus Control of Complex and Multi-scale Networks with Network Uncertainty and Adversary	W911NF-12-1-0223
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER 611102
6. AUTHORS George Yin, Le Yi Wang	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES	8. PERFORMING ORGANIZATION REPORT NUMBER
Wayne State University 5057 Woodward Ave. 13th Floor Detroit, MI 48202 -4050	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES)	10. SPONSOR/MONITOR'S ACRONYM(S) ARO
U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	11. SPONSOR/MONITOR'S REPORT NUMBER(S) 61865-MA.24

12. DISTRIBUTION AVAILIBILITY STATEMENT

Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

The project is motivated by the needs of more advanced methodology for filtering, control, coordination, and dynamic reconfiguration of networked systems. Development of such systems is of essential values for Army's mission to gather military intelligence information and to assist military operations in hostile encounters. We have worked on several problems arising in modeling, coordination, control, computation, and analysis of networked systems. The following is a list of tasks accomplished.

15. SUBJECT TERMS

Consensus Control, Complex and Multi-scale Networks, Network Uncertainty

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UU	UU	UU	UU		Gang George Yin
					19b. TELEPHONE NUMBER 313-577-2479

Report Title

Final Report: Consensus Control of Complex and Multi-scale Networks with Network Uncertainty and Adversary

ABSTRACT

The project is motivated by the needs of more advanced methodology for filtering, control, coordination, and dynamic reconfiguration of networked systems. Development of such systems is of essential values for Army's mission to gather military intelligence information and to assist military operations in hostile encounters. We have worked on several problems arising in modeling, coordination, control, computation, and analysis of networked systems. The following is a list of tasks accomplished.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received		Paper
07/04/2013	1.00	Wei Feng, G. Yin, Le Yi Wang. Joint State and Event Observers for Linear Switching Systems under Irregular Sampling, Automatica, (02 2013): 894. doi:
07/04/2013	3.00	G. Yin, Le Wang, Yu Sun, David Casbeer, Raymond Holsapple, Derek Kingston. Asymptotic Optimality for Consensus-Type Stochastic Approximation Algorithms using Iterate Averaging, J. Control Theory Applications, (01 2013): 1. doi:
07/04/2013	2.00	G. Yin, Araz Hashemi, Le Yi Wang. Sign-Regressor Adaptive Filtering Algorithms for Markovian Parameters, Asian Journal of Control, (10 2013): 0. doi:
07/21/2014	9.00	Q. Song, G. Yin, Q. Zhang. WEAK CONVERGENCE METHODS FOR APPROXIMATION OFTHE EVALUATION OF PATH-DEPENDENT FUNCTIONALS, SIAM J on Control and Optimization, (10 2013): 4189. doi:
07/22/2014	10.00	F. Xi, G. Yin. Almost sure stability and instability for switching-jump-diffusionsystems with state-dependent switching, Journal of Mathematical Analysis and Applications, (11 2012): 460. doi:
07/22/2014	11.00	S. Kan, G. Yin, L.Y. Wang. Parameter estimation in systems with binary-valued observations and structural uncertainties, International Journal of Control, (04 2014): 1061. doi:
07/22/2014	12.00	G. Yin, N. Baran, C. Zhu. Feynman-Kac formula for switchingdiffusions: connections of systems of partialdifferential equations and stochasticdifferential equations, Advanced Difference Equations, (11 2013): 1. doi:
07/22/2014	13.00	H. Li, G. Yin, J. Ye. Asymptotic stability of switching diffusionshaving sub-exponential rates of decay, Dynamic Systems and Applications, (05 2013): 65. doi:
07/22/2014	14.00	L. Xu, L.Y. Wang, G. Yin, W. Zheng. Enhanced feedback robustness against communication channelmultiplicative uncertainties via scaled dithers, Systems & Control Letters, (03 2014): 25. doi:
07/22/2014	15.00	L.Y. Wang, G. Yin, C. Li, W. Zheng. Feedback systems with communications: integrated study of signalestimation, sampling, quantization, and feedback robustness, Ineternational Journal of Adaptive Control and Signal Processing, (05 2014): 496. doi:
09/02/2015	18.00	B. Mu, H.-F. Chen, L.Y. Wang, G. Yin. Characterization and identification of matrix fraction descriptions for LTI systems,, SIAMJ Control Optimization, (11 2014): 3694. doi:
09/02/2015	23.00	J. Bao, G. Yin, C. Yuan, L.Y. Wang. Exponential ergodicity for retarded stochastic differential equations, Applicable Analysis, (09 2014): 2330. doi:
09/02/2015	21.00	F. Wu, G. Yin, T. Tian. Gene regulatory networks driven by intrinsic noise with two-time scales: A stochastic averagingapproach, Frontiers of Mathematics in China, Frontier of Mathematics China , (08 2014): 947. doi:

09/02/2015	20.00	Q. Yuan, G. Yin. , Analyzing convergence and rates of convergence of particle swarm optimization algorithms using stochastic approximation methods, IEEE TRANSACTIONS ON Automatic Control, (07 2015): 1760. doi:
09/02/2015	19.00	J. Guo, L.Y. Wang, G. Yin, Y. Zhao, J.-F. Zhang. Asymptotically efficient identification of FIR systems with quantized observations and general quantized inputs, Automatica, (05 2015): 113. doi:
09/03/2015	17.00	F. Wu, G. Yin, L.Y. Wang. Razumikhin-Type Theorems on Moment Exponential Stability of Stochastic Functional Differential Equations with the Two-time-scale Markovian Switching, Mathematical Control and Related Fields, (09 2015): 697. doi:

TOTAL: **16**

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received	Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

• George Yin, Distinguished Speaker, 9th International Conference on Differential Equations and Dynamical Systems, May 2015, Dallas, TX.

• George Yin, Three seminar talks, Vietnam Institute for Advanced Study in Mathematics, Hanoi, Vietnam, April, 2015

• George Yin, Two seminar talks, Vinh University, Vietnam, April 2015.

• George Yin, Seminar talk, Ho Chi Minh City University of Technology, April 2015.

• George Yin, Two seminar talks, Ho Chi Minh City University of Natural Science, April 2015.

• George Yin, Science Colloquium, Texas A\&M Qatar, Feb. 2015.

• George Yin, Colloquium talk, Department of Mathematics, University of Central Florida, Feb. 2015.

• George Yin, Applied Mathematics Seminar, University of Puerto Rico, Rio Piedras, Feb. 2015.

• George Yin, Probability Seminar, National Central University, Taiwan, Jan., 2015.

• George Yin, Probability Seminar, Academia Sinica, Institute of Mathematics, Taiwan, Jan., 2015.

• George Yin, Applied Mathematics Seminar, University of Georgia, Jan., 2015.

• George Yin, A series of lectures given at School of Finance and Statistics, Eastern China Normal University, Sept., 2014.

• George Yin, Colloquium talk, School of Mathematics and Statistics, Huazhong University of Science and Technology, August. 2014.

• George Yin, Invited speaker, 10th Workshop on Markov Processes and Related Topics, Xian, China, Aug. 2014.

• L.Y. Wang, Tsinghua University, May, 2015

• L.Y. Wang, Chinese Academy of Sciences, May, 2015.

• L.Y. Wang, Jiangsu University, May, 2015.

• L.Y. Wang, Chongqing University, May, 2015

• L.Y. Wang, Jiangsu University, January, 2015.

Number of Presentations: 19.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received		Paper
07/04/2013	4.00	Shaobai Kan, G. Yin, Le Yi Wang. Parameter Estimation in Systems with Binary-Valued Observationsand Structural Uncertainties, INTERNATIONAL JOruanl of Control (12 2012)
07/04/2013	5.00	Jianhai Bao, G. Yin, Chenggui Yuan, Le Yi Wang. Exponential mixing for retarded stochastic differential equations, J Theoretical Probability (07 2013)
09/02/2015	22.00	A. Hashemi, G. Yin, L.Y. Wang. Sign-error adaptive filtering algorithms involving Markovian parameters, Mathematical Control and Related Fields (to appear) (02 2015)

TOTAL: **3**

Number of Manuscripts:

Books

Received	Book

Received		Book
07/04/2013	6.00	Qi He, Le Yi Wang, G. Yin. System Identification Using Regular and Quantized Observation : Applications of Large Deviations Principles, New York: Springer, (01 2013)
07/04/2013	7.00	Héctor Jasso-Fuentes, G. Yin. Advanced Criteria for controlled Markov-Modulated Diffusions in an Infinite Horizon: Overtaking, Bias,and Blackwell Optimality, Beijing: Science Press, (06 2013)
07/04/2013	8.00	G. Yin, Hanqin Zhang, Qing Zhang. Applications of Two-time-scaleMarkovian Systems, Beijing: Science Press, (06 2013)

TOTAL: **3**

Received		Book Chapter
07/22/2014	16.00	G. Yin. Numerical Methods forContinuous-time Stochastic ControlProblems, Springer-Verlag, London.: Springer ; Encyclopedia of Systems and Control, (04 2014)

TOTAL: **1**

Patents Submitted

Patents Awarded

Awards

- Le Yi Wang: Faculty Research Excellence Award, College of Engineering, Wayne State University, 2015
- George Yin, SIAM Fellow, 2015.

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Dang Hai Nguyen	0.50	
Di Zhang	0.20	
FTE Equivalent:	**0.70**	
Total Number:	**2**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
Jin Guo	0.30
Biqiang Mu	0.80
Yang Wang	0.50
FTE Equivalent:	**1.60**
Total Number:	**3**

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
George Yin	0.11	
Le Yi Wang	0.11	
FTE Equivalent:	**0.22**	
Total Number:	**2**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED	Discipline
Joseph Francis Willard	0.00	Mathematics (doing undergraduate research with PI)
FTE Equivalent:	**0.00**	
Total Number:	**1**	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:...... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):...... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:...... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:...... 0.00

Names of Personnel receiving masters degrees

NAME
Dalaal Abdulkarim Balawi
Lu Yan
Total Number: **2**

Names of personnel receiving PHDs

NAME
Quan Yuan (0)
Nicholas Baran (0)
Lijian Xu (0.3)
Zhixin Yang (0)
Total Number: **4**

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

See attachment

Technology Transfer

Project Report: W911NF-12-1-0223, 61865-MA, June 2012-May, 2015

Consensus Control of Complex and Multi-scale Networks

George Yin and Le Yi Wang, Wayne State University, Detroit, MI 482902, 313-577-2479 (Dept.), 313-577-4715, gyin@math.wayne.edu, lywang@wayne.edu

The project is motivated by the needs of more advanced methodology for filtering, control, coordination, and dynamic reconfiguration of networked systems. Development of such systems is of essential values for Army's mission to gather military intelligence information and to assist military operations in hostile encounters. We have worked on several problems arising in modeling, coordination, control, computation, and analysis of networked systems. The following is a list of tasks accomplished.

1. System Identification and Parameter Estimation

   1) Joint observability and sampling complexity were established in our paper in one of the flagship journal in control theory, Automatica [7]. We extended Shannon's sampling theorem and our recent results on sampling complexity to joint estimation problems. Observer design and convergence analysis are conducted for systems under noisy observations. It is shown that our algorithms converge strongly with an error bound of the order $O(1/N)$.

   2) Summarizing our work on identifications of systems with regular and quantized sensors, we developed large deviations estimates for such identification problems. A SpringerBrief in Mathematics was published in 2013 (Ref. [2]). Although there are many excellent works on large deviations and identifications, our work appears to be the first one putting the large deviations framework for identification problems. Observations under regular, binary, and quantized sensors have been considered. Complexity issues are also treated.

   3) We studied identification of linear systems with binary-valued observations generated via fixed thresholds. In addition to stochastic noises, the systems are also subject to many structural uncertainties, including deterministic unmodeled dynamics, nonlinear model mismatch, and sensor observation bias. Since binary-valued observations can supply only limited information on the signals, truncated empirical measures were introduced to extract further information for system identification. An effective identification algorithm was constructed based on the proposed empirical measures. Optimal identification errors, time complexity, optimal input design, and impact of disturbances, unmodeled dynamics, observation bias, and nonlinear model mismatch are thoroughly investigated in a stochastic information framework. Asymptotic upper and lower bounds are established on identification errors [13].

4) Estimation of states and events in randomly switching systems is studied under irregular and random sampling schemes. Probabilistic characterization of observability is presented under various sampling schemes and regime-switching processes. The characterization is derived on the basis of our recent results on sampling complexity for system observability. Observer design and algorithms are developed [6].
5) The paper [16] shows that the matrix fraction description, given by a pair {A(z), B(z)} of matrix polynomials of z, for a linear time-invariant system may not be unique even if A(z) is monic, A(z), and B(z) have no common left factor, and the matrix coefficients corresponding to the highest-order terms of A(z) and B(z) are full row rank. The orders of all possible MFDs of a given system are completely characterized. Testing criteria for determining whether a matrix pair is an MFD of the system are derived, which involve rank tests of certain Toeplitz matrices derived from either the impulse response or output correlation functions of the system. A decision procedure is devised that generates sequentially all MFDs for a given system. Identification algorithms are introduced that estimate all MFDs of a given system from its input-output data or output data only. The results are then extended to cover ARMAX systems.
6) The papers [17] and [18] introduce identification algorithms for finite impulse response systems under quantized output observations and general quantized inputs. While asymptotically efficient algorithms for quantized identification under periodic inputs are available, their counterpart under general inputs has encountered technical difficulties and evaded satisfactory resolutions. Under quantized inputs, this paper resolves this issue with constructive solutions. A two-step algorithm is developed, which demonstrates desired convergence properties including strong convergence, mean-square convergence, convergence rates, asymptotic normality, and asymptotical efficiency in terms of the Cramér–Rao lower bound. Some essential conditions on input excitation are derived that ensure identifiability and convergence. It is shown that by a suitable selection of the algorithm's weighting matrix, the estimates become asymptotically efficient. The strong and mean-square convergence rates are obtained. Optimal input design is given. Also the joint identification of noise distribution functions and system parameters is investigated. Numerical examples are included to illustrate the main results of this paper.

2. Stochastic Systems, Systems with Delays, and Systems with Random Switching
   1) Continuing on our work [J. Differential Eqs., 2012], we developed moment exponential stability of stochastic functional equations (SFDEs) with Markovian switching, in which a two-time scale continuous-time Markov chain is used to represent the switching process. Under suitable conditions, there is a limit system. Using the limit system as a bridge, we establish a Razumikhin-type theorem on moment exponential stability. By virtue of the Razumikhin-type theorem, we further deduce mean-square exponential stability results for stochastic Volterra delay-integro-differential equations (SVDIDEs), stochastic delay differential equations (SDDEs), and stochastic differential equations (SDEs) with two-time-scale Markovian switching (see [15]).

2) As another effort of treating systems with delays, we considered different types of environmental noises in population systems. These noises play crucial roles and have significant impact on the evolution and biodiversity. To understand the effects of different types of noises on the asymptotic properties of the populations, we studied the influence of inherent net birth noise and the interaction noise among stochastically perturbed population systems (see [1]).
3) We developed almost sure stability criteria for switching-jump-diffusion systems with state-dependent switching. By means of introducing certain auxiliary Markov chains and constructing order-preserving couplings, upper and lower ‘‘stability envelops’’ were constructed, which lead to systems with ‘‘upper and lower’’ approximating Markov chains. Using these approximations, sufficient conditions that are relatively easily verifiable for the almost sure stability and instability were obtained. When the jump process is missing, it is demonstrated that the techniques work equally well and provide a way to analyze the corresponding switching diffusion systems with x-dependent switching. In addition, stochastic stabilization and destabilization are examined (Ref. [11]).
4) The paper [22] establishes ergodic properties for Markovian semigroups generated by segment processes associated with several classes of retarded stochastic differential equations (SDEs) with constant/variable/distributed time lags. It derives exponential ergodicity for (a) retarded SDEs by the Arzelà–Ascoli tightness characterization of the space C equipped with the uniform topology, (b) neutral SDEs with continuous sample paths by a generalized Razumikhin-type argument and a stability-in-distribution approach, and (c) retarded SDEs driven by jump processes using the Kurtz criterion of tightness for the space D endowed with the Skorohod topology.

3. Stochastic Algorithms for Consensus, Swarming, and Adaptive Filtering

1) Recently, much progress has been made on particle swarm optimization (PSO). A number of works have been devoted to analyzing the convergence of the underlying algorithms. Nevertheless, in most cases, rather simplified hypotheses are used. For example, it often assumes that the swarm has only one particle. In addition, more often than not, the variables and the points of attraction are assumed to remain constant throughout the optimization process. In reality, such assumptions are often violated. Moreover, there are no rigorous rates of convergence results available to date for the particle swarm, to the best of our knowledge. In this paper, we consider a general form of PSO algorithms, and analyze asymptotic properties of the algorithms using stochastic approximation methods. We rewrite the PSO procedure as a stochastic approximation type iterative algorithm. Then we analyze its convergence using weak convergence method. It is proved that a suitably scaled sequence of swarms converge to the solution of an ordinary differential equation. We also establish certain stability results. Moreover, convergence rates are ascertained by using weak convergence method. A centered and scaled sequence of the estimation errors is shown to have a diffusion limit. The paper was published in another flagship journal IEEE Transactions on Automatic Control in 2015 [19].

2) We developed a post-iteration averaging algorithm to achieve asymptotic optimality in convergence rates of stochastic approximation algorithms for consensus control with structural constraints. The algorithm involves two stages. The first stage is a coarse approximation obtained using a sequence of large stepsizes. Then the second stage provides a refinement by averaging the iterates from the first stage. We show that the new algorithm is asymptotically efficient and gives the optimal convergence rates in the sense of the best scaling factor and ``smallest'' possible asymptotic variance. (Ref. [5]).

3) Motivated by reduction of computational complexity, we develop sign-error adaptive filtering algorithms for estimating time-varying system parameters in [3]. Different from the previous work on sign-error algorithms, the parameters are time-varying and their dynamics are modeled by a discrete-time Markov chain. A distinctive feature of the algorithms is the multi-time-scale framework for characterizing parameter variations and algorithm updating speeds. This is realized by considering the stepsize of the estimation algorithms and a scaling parameter that defines the transition rate of the Markov jump process. Depending on the relative time scales of these two processes, suitably scaled sequences of the estimates are shown to converge to either an ordinary differential equation, or a set of ordinary differential equations modulated by random switching, or a stochastic differential equation, or stochastic differential equations with random switching. Using weak convergence methods, convergence and rates of convergence of the algorithms are obtained for all these cases; see [12, 20].

4. Stochastic Systems and Control

1) In many applications, one needs to evaluate a path-dependent objective functional V associated with a continuous-time stochastic process X. Due to the nonlinearity and possible lack of Markovian property, more often than not, V cannot be evaluated in closed form, and only Monte Carlo simulation or numerical approximation is possible. In addition, the calculations often require the handling of stopping times, the usual dynamic programming approach may fall apart, and the continuity of the functional becomes the main issue. Our work published in SIAM J. Control and Optimization (another flagship journal in control theory) developed a numerical scheme so that an approximating sequence of path-dependent functionals converges to V; see [8].

2) As a continuation of our work [Yin and Zhang, 1998, Springer] on a comprehensive treatment of two-time-scale Markov chains with finite state spaces, the monograph [9] focuses on applications that were considered after the publication of the aforementioned book. In addition, countable state space cases and switching diffusion limits are also treated. After reviewing previous results on two-time-scale Markov chains with a finite state space, systems having countable state spaces are treated, and switching diffusion limits are discussed as well. In addition, state-dependent generators are dealt with, which largely extends the applicability of the results. The second part of the book is devoted to a number of applications arising from manufacturing, queueing systems, financial engineering,

insurance risk etc. Hopefully, these results will be of interests to many people working in the related areas and an even wider range of applications. Devoted to large scale and complex systems, it encompasses such applications as insurance and risk management, financial engineering, queueing networks, and the Wonham filtering among others. With seemingly diverse range of applications, the different problems are closely connected through the central theme of two-time-scale formulation. We hope that this work can serve as a user guide for modeling, analysis, optimization, and computation for a wide variety of Markovian systems; see [3].

3) Traditional stochastic control problems in the infinite horizon are concerned with the well-known discounted criterion and the average criterion (or ergodic criterion). It is widely recognized that these two basic criteria have certain deficiencies. The first one concentrates on the performance of early period of time since the reward (or cost) has a diminishing weight for long-time intervals, whereas the second one focuses on asymptotic behavior, but it does not take into account the behavior on finite intervals. As a result, each of these two criteria has its limitations. The first one overlooks, in some sense, any large-time behavior, whereas the second one cannot provide any insight into finite horizon performance. To overcome the difficulties and drawbacks, the so-called selective or advanced criteria have been invented. The book focuses on the so-called advanced or selective control criteria for switching diffusion systems. Since the initiation of the study of stochastic control, there have been numerous papers on infinite horizon control systems. Nevertheless, the results on advanced criteria are still scarce. There have been only a handful of papers focusing on advanced criteria. Moreover, most of the existing papers on advanced criteria have focused on Markov decision processes, continuous-time Markov chains, and controlled diffusions. The work on that of Markov-modulated diffusions is still in its infancy. Facing the need, the monograph [4] takes up the issue of studying advanced criteria for controlled switching diffusions. We survey some of the recent progress and substantially update and extend the known results.

4) The work [21] focuses on gene regulatory networks driven by intrinsic noise with two-time scales. It uses a stochastic averaging approach for these systems to reduce complexity. Comparing with the traditional quasi-steady-state hypothesis (QSSH), our approach uses stochastic averaging principle to treat the intrinsic noise coming from both the fast-changing variables and the slow-changing variables, which yields a more precise description of the underlying systems. To provide further insight, this paper also investigates a prototypical two-component activator-repressor genetic circuit model as an example. If all the protein productions were linear, these two methods would yield the same reduction result. However, if one of the protein productions is nonlinear, the stochastic averaging principle leads to a different reduction result from that of the traditional QSSH.

Publications

[1] F. Wu and G. Yin, Environmental noise impact on regularity and extinction of population systems with infinite delay, Journal of Mathematical Analysis and Applications, 396 (2012), 772-785.

[2] Q. He, L.Y. Wang, and G. Yin, System Identification Using Regular and Quantized Observation : Applications of Large Deviations Principles, SpringerBriefs, XII+95pp., New York, 2013.

[3] G. Yin, H.Q. Zhang, and Q. Zhang, Applications of Two-time-scale Markovian Systems, Science Press, Beijing, China, 2013, vii+209 pp.

[4] H. Jasso-Fuentes and G. Yin, Advanced Criteria for controlled Markov-Modulated Diffusions in an Infinite Horizon: Overtaking, Bias, and Blackwell Optimality, Science Press, Beijing, China, 2013, xi+139 pp.

[5] G. Yin, L.Y. Wang, Y. Sun, D. Casbeer, R. Holsapple, and D. Kingston, Asymptotic optimality for consensus-type stochastic approximation algorithms using iterate averaging, Journal of Control Theory and Applications, 11 (2013), 1-9.

[6] W. Feng and L. Y. Wang, State and event estimation for regime-switching systems under irregular and random sampling schemes, Communications in Information and Systems, 12 (2013), 15-40.

[7] L. Y. Wang, W. Feng, G. Yin, Joint State and Event Observers for Linear Switching Systems under Irregular Sampling, Automatica, , 49 (2013) 894–905.

[8]Q. Song, G. Yin, and Q. Zhang, Weak convergence methods for approximation of evaluation on path-dependent functionals, SIAM Journal on Control and Optimization, 51 (2013), 4189–4210.

[9] N. Baran, G. Yin, and C. Zhu, Feynman-Kac formula for switching diffusions: Connections of systems of partial differential equations and stochastic differential equations, Advances in Difference Equations, 2013 (2013): 315.

[10]H. Li, G. Yin, and J. Ye, Asymptotic stability of switching diffusions having sub-exponential rates of decay, Dynamic Systems and Applications, 22 (2013), 65--94.

[11] F. Xi and G. Yin, Almost sure stability and instability for switching-jump-diffusion systems with state-dependent switching, Journal of Mathematical Analysis and Applications, 400, (2013), 460-474.
[12] G. Yin, A. Hashemi, and L.Y. Wang, Sign-regressor adaptive filtering algorithms for Markovian parameters, Asian Journal of Control, 16 (2014), 95-106.
[13] S. Kan, G. Yin, and L.Y. Wang, Parameter estimation in systems with binary-valued observations and structural uncertainties, International Journal of Control, 87 (2014), 1061–1075.
[14] L.Y. Wang, G. Yin, C. Li, and W. Zheng, Feedback systems with communications: Integrated study of signal estimation, sampling, quantization, and feedback robustness, International Journal of Adaptive Control and Signal Processing, 28 (2014), 496–522.
[15] F. Wu, G. Yin, and L.Y. Wang, Razumikhin-Type Theorems on Moment Exponential Stability of Stochastic Functional Differential Equations with the Two-time-scale Markovian Switching, Mathematical Control and Related Fields, Vol. 5 (2015), 697-719.
[16] Biqiang Mu, Hanfu Chen, Le Yi Wang, George Yin, Characterization and identification of matrix fraction descriptions for LTI systems, SIAM J. Control and Optimization, Vol. 52, No. 6, pp. 3694–3721, 2014.
[17] Jin Guo, Le Yi Wang, George Yin, Yanlong Zhao, Jifeng Zhang, Asymptotically efficient identification of FIR systems with quantized observations and general quantized inputs, Automatica, Vol. 57, pp. 113-122, 2015.
[18] Jin Guo, Le Yi Wang, George Yin, Yanlong Zhao, Jifeng Zhang, Identification of FIR Systems with Quantized Inputs and Observations, SYSID, Beijing, Oct. 19-21, 2015.
[19] Q. Yuan and G. Yin, Analyzing convergence and rates of convergence of particle swarm optimization algorithms using stochastic approximation methods, IEEE Transactions on Automatic Control, Vol. 60 (2015), 1760-1773.
[20] A. Hashemi, G. Yin, L.Y. Wang, Sign-error adaptive filtering algorithms involving Markovian parameters, to appear in Mathematical Control and Related Fields.
[21] F. Wu, G. Yin, and T. Tian, Gene regulatory networks driven by intrinsic noise with two-time scales: A stochastic averaging approach, Frontiers of Mathematics in China, Vol. 9 (2014) 947-963.
[22] J. Bao, G. Yin, C. Yuan. and L. Y. Wang, Exponential ergodicity for retarded stochastic differential equations, to appear in Applicable Analysis, Vol. 93 (2014), 2330-2349.